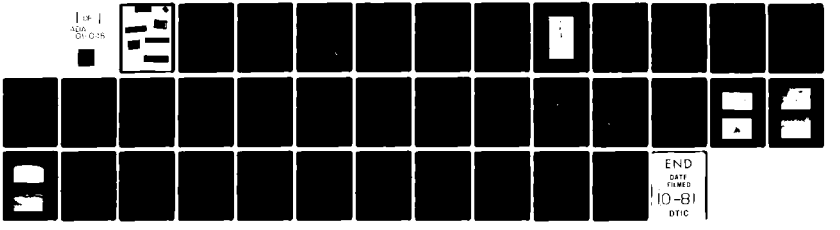
AD-A105 048 BALK (KENNETH) AND ASSOCIATES INC ST LOUIS MO F/G 13/13
NATIONAL DAM SAFETY PROGRAM. PINNACLE LAKE DAM (MO 30923), UPPE--ETC(U)
NOV 78 E H BAUMEYER, L KUNZE DACW43-78-C-0169

UNCLASSIFIED NL



END
DATE FILMED
10-81
DTIC

LEVEL II

Pinnacle Lake Dam (MO 30923).
Upper Mississippi - Mississippi - Kaskaskia -
St. Louis Basin. Montgomery County, Missouri.
Phase 1 Inspection Report.

9 Final rept.
15 DACW43-78-C-0169
10 Ervin H. /Baumeyer Lutz /Kunze

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A105 048 / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Phase I Dam Inspection Report National Dam Safety Program Pinnacle Lake Dam (MO 30923) Montgomery County, Missouri	5. TYPE OF REPORT & PERIOD COVERED Final Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Kenneth Balk and Associates, Inc.	8. CONTRACT OR GRANT NUMBER(s) DACW43-78-C-0169
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	12. REPORT DATE November 1978 13. NUMBER OF PAGES Approximately 30
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Pinnacle Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Pinnacle Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood
2) Overtopping could result in dam failure.
3) Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED
Chief, Engineering Division
Date 26 FEB 1979

APPROVED BY: SIGNED
Colonel, CE, District Engineer
Date 26 FEB 1979

PINNACLE LAKE DAM

MONTGOMERY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30923

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY

Kenneth Balk & Associates, Inc.
St. Louis, Missouri
Shannon & Wilson, Inc.
St. Louis, Missouri

PREPARED FOR

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

NOVEMBER, 1978

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Pinnacle Lake
State Located	Missouri
County Located	Montgomery County
Stream	Tributary To Pinnacle Creek
Date of Inspection	August 25, 1978

Pinnacle Lake Dam, No. 30923 was inspected using the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U. S. Army, Washington, D.C., with the help of Federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines are considered to represent a consensus of the engineering profession.

Pinnacle Lake Dam was visually inspected by an interdisciplinary team of engineers from Kenneth Balk & Associates, Inc. and Shannon & Wilson, Inc. The purpose of the inspection was to make a preliminary assessment of the general condition of the dam with respect to safety in order to determine if, in the opinion of the interdisciplinary team, the dam poses recognizable hazards to human life or property. This assessment is based solely upon data made available and visual evidence observed during the site visit.

To make a complete assessment of the safety of the dam would require detailed studies and engineering analyses beyond the scope of this preliminary assessment.

Based on the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. The estimated damage zone extends six miles downstream of the dam. Immediately downstream of the dam is a trailer camping area. Within the damage zone are three farmhouses and three farm complexes. The flood plain is farmed. Pinnacle Dam is in the intermediate size classification since it impounds more than 1,000 acre feet of water, but less than 50,000 acre feet.

The inspection and evaluation indicate that the spillway of Pinnacle Lake does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. Pinnacle Lake is an intermediate size dam with a high hazard potential, required by the guidelines to pass the PMF. Considering the high hazard potential to loss of life and property downstream of the dam, the outlet facilities of Pinnacle Lake Dam should be able to pass the PMF without overtopping the dam. However, it was determined that the spillway will only pass approximately 5 percent of the PMF without overtopping the dam.

The evaluation of Pinnacle Lake also indicated that the spillway will not pass the 100-year flood; that is, a flood having a 1 percent chance of being equalled or exceeded during any given year.

It should be noted that the aforementioned results were obtained by neglecting the storage provided by a significant number of ponds and abandoned clay pits present in the watershed.

Deficiencies visually observed by the inspection team were brush on the upstream and downstream slope of the embankment, a six foot four inch diameter pipe at the toe, which is partially closed with a water flow of approximately 80 GPM. According to hearsay, the dam breached some years ago and was repaired. Other deficiencies found were the lack of seepage records, operational records, seepage and stability analyses comparable to the requirements of the Recommended Guidelines and seismic stability analyses.

The lack of seepage and stability analyses on record is a deficiency that should be corrected.

It is recommended that action be taken in the near future to correct or control the deficiencies described. A detailed report discussing each of these deficiencies is attached.

Ervin H. Baumeyer, P.E.
Principal-In-Charge
Kenneth Balk and Associates, Inc.
St. Louis, Missouri

Lutz Kunze, P.E.
Principal Engineer
Shannon & Wilson, Inc.
St. Louis, Missouri

Overview of Lake and Dam

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
PINNACLE LAKE DAM - ID NO. 30923

TABLE OF CONTENTS

Paragraph No.	Title	Page No.
	SECTION 1 - PROJECT INFORMATION	
1.1	General	1
1.2	Description of Project	1-2
1.3	Pertinent Data	2-3
	SECTION 2 - ENGINEERING DATA	
2.1	Design	4
2.2	Construction	4
2.3	Operation	4
2.4	Evaluation	4
	SECTION 3 - VISUAL INSPECTION	
3.1	Findings	5-6
3.2	Evaluation	6
	SECTION 4 - OPERATIONAL PROCEDURES	
4.1	Procedures	7
4.2	Maintenance of Dam	7
4.3	Maintenance of Operating Facilities	7
4.4	Description of Any Warning System in Effect	7
4.5	Evaluation	7
	SECTION 5 - HYDRAULIC/HYDROLOGIC	
5.1	Evaluation of Features	8
	SECTION 6 - STRUCTURAL STABILITY	
6.1	Evaluation of Structural Stability	9
	SECTION 7 - ASSESSMENT/REMEDIAL MEASURES	
7.1	Dam Assessment	10
7.2	Remedial Measures	10

APPENDIX

A . Hydrologic and Hydraulic Analyses Methodology

LIST OF PLATES

Plate No.	Title
1	Vicinity Topography
2	Location Map
3	Top of Dam Elevations
4	Top of Dam Profile and Cross Section

LIST OF PHOTOGRAPHS

Photo No.	Title
1	Overview of Lake and Dam
2	Crest of Dam
3	Rock Outcrop on East Abutment
4	Old Spillway Outlet Works
5	Principal Spillway Entrance
6	Spillway Exit

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Pinnacle Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon data made available and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure built on a tributary to Pinnacle Creek in Montgomery County, Missouri. Topography adjacent to the valley is rolling to steep. Topography in the vicinity of the dam is shown on Plate 1.

(2) The principal spillway, consisting of a steel and concrete box structure, drops the flow into an 84 inch diameter steel pipe which extends through the dam, then drops into a small pool downstream of the toe. The spillway is located at Station 5+67 of the embankment.

(3) Pertinent physical data are given in paragraph 1.3 below.

b. Location. The dam is located in the southeastern portion of Montgomery County, Missouri, as shown on Plate 2. The lake formed by the dam is on the Missouri-Montgomery County Pinnacle Lake quadrangle sheet in the NE 1/4 of Section 24, T47N, R5W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, this dam and impoundment is in the intermediate size category.

d. Hazard Classification. Guidelines for determining hazard classification are presented in the same guidelines as referenced in paragraph c. Based on referenced guidelines, the Corps of Engineers has determined that this dam is in the High Hazard Classification and thus has been selected by the Corps of Engineers for a Phase I Inspection.

e. Ownership. It is reported that the dam is owned by Pinnacle Lake Estates Association, Inc. R.R. No. 1, Box 129B, New Florence, Missouri 65363.

f. Purpose of Dam. The dam forms a recreational lake.

g. Design and Construction History. There are no known design plans or construction records. According to the "Inventory of Dams", the dam was completed in 1965 and was partially breached some years later. According to a report dated June 25, 1974, by J. Hadley Williams Geologist and Chief, Applied Engineering & Urban Geology, Missouri Geological Survey, the leak was caused by a structural failure of the drop inlet spillway. A weld broke at the junction of the inclined portion of the spillway pipe. The dam was evidently repaired and a new spillway structure installed in the embankment. The previous spillway was partially sealed by welding a steel plate in the pipe at the downstream end, however, the upstream end was not found. Much of the construction history was deduced from the visual evidence.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, and spillway discharge all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 4749 acres.

b. Discharge at Damsite.

(1) Spillway - 979.8 cfs. at maximum pool.

(2) Estimated experienced maximum flood - approximately 2 feet below top of dam.

c. Elevation (U.S.G.S.)

(1) Top of dam - 620.3 at low point.

(2) Spillway crest - 617.0.

(3) Streambed at centerline of dam - 580 ±

(4) Maximum tailwater - unknown.

d. Reservoir. Length of maximum pool - 4000 feet ±.

e. Storage (Acre-feet).

(1) Normal - 2184.

(2) Maximum - 2606.8.

f. Reservoir Surface (Acres).

(1) Top of dam - 138.

(2) Spillway crest - 118.

g. Dam.

(1) Type - earth embankment.

(2) Length - 800 feet.

(3) Height - 50 feet maximum.

(4) Top width - 15 feet.

(5) Side Slopes (measured by a slope meter/inclinometer in degrees and converted to ratios).

(a) Downstream - 2.5 H. to 1 V

(b) Upstream - 3 H. to 1 V to waterline. Visibly flatter below waterline.

(6) Zoning - Unknown.

(7) Impervious core - unknown

(8) Cutoff - unknown

(9) Grout curtain - unknown

h. Diversion and Regulating Tunnel. - None.

i. Principal Spillway.

(1) Type - Steel and concrete drop structure with 84 inch diameter steel outlet pipe.

(2) Effective weir length - 49.2 feet.

(3) Crest elevation - 617 U.S.G.S.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design data were found to be readily available.

2.2 CONSTRUCTION

The dam was completed in 1965. Remedial construction relative to repairing a partial breach of the embankment was only evident by the presence of what was apparently the old spillway pipe. However, this was sufficient to be considered in this report.

2.3 OPERATION

No records of the maximum loading on the dam were available.

2.4 EVALUATION

a. Availability. Some geological data were available, consisting of several Geologic Reports, by the Missouri Geological Survey.

b. Adequacy. No engineering data was available to make a detailed assessment of the design, construction, and operation of the dam. The lack of seepage and stability analyses comparable to the requirements of the Recommended Guidelines is considered a deficiency which should be corrected. An engineer experienced in the design of dams should be retained to perform detailed seepage and stability analyses.

c. Validity. No engineering data on design were available, however, the geological data was considered valid.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

A. General. A visual inspection of the Pinnacle Lake Corp. Dam was carried out on August 25, 1978. Personnel making inspection were employees of Kenneth Balk and Associates, Inc. and Shannon and Wilson, Inc. of St. Louis and included civil, geotechnical, and structural engineers and an engineering geologist. Specific observations are discussed below.

B. Dam. The inspection team observed the following at the dam. The dam is an earth structure with a gravel road running across the crest. Brush and some small trees are growing on the downstream slope of the embankment. Upstream erosion protection consists of a cover of grass.

No detrimental settlement, depressions, cracking, erosion, animal burrows or slope instability was observed on or near the embankment. There are no signs on the embankment indicating the limits of reconstruction reported in section 1.2g., however, a six foot four inch diameter iron pipe, apparently the original spillway, was found at the toe. No seepage was observed, however, the abandoned spillway pipe, although partially closed with a welded metal plate, was flowing at a rate of approximately 80 gallons per minute on the day of the inspection. Visually, the water appeared to be clear, but tests for sedimentation were not made.

The dam has approximately three (3) feet of freeboard.

C. Appurtenant Structures. The spillway, consisting of a steel and concrete drop structure with a trash rack is located adjacent to Station 5+67 (see Plate 3). The spillway drops the flow into an 84 inch diameter steel outlet pipe which carries the flow through the dam, dropping the flow into a small pool located downstream from the toe of the dam. The spillway structure and outlet pipe are in good condition, and discharge will not endanger the integrity of the dam. A boat launching ramp is located near the right abutment. The crest of the dam has a swale at this location with its lowest point being at least 2.8 feet below the majority of the crest. This swale was apparently constructed to provide convenient access to the boat launching ramp. In the opinion of the inspecting team, this swale was not intended to serve as an overflow spillway, since flow through it would flow to the left down the embankment slope.

D. Reservoir Area. No wave wash, excessive erosion or slides were observed along the shore of the reservoir.

E. Damsite Geology.

Left Abutment. The area around the left abutment consists of large outcrops of mostly massive light gray sandstone (St. Peter Formation). At places it is moderately bedded. The sandstone consists of sand grains of medium size, rounded, spherical and frosted. It is sparsely jointed and the majority of the joints are bedding joints.

Joints dip 10^{o} NW

Strike 60^{o} NW

Joint openings: 1/8 inch to 3 inches

Filling material: Calcareous and Siliceous

Open joints 35%, closed joints 65%

A few joints have dip 75^{o} NW, strike 40^{o} NE

Right Abutment: The area around the right abutment consists of a continuation of the same rock formation as exposed on the left abutment. At places, the sandstone is othro-quartzatic and white in color, mostly massive but medium soft, occasionally medium to thinly bedded and sparsely jointed. Bedding about 5^{o} almost west, strike almost NS. Dip and strike of joints are approximately the same as those on left abutment.

3.2 EVALUATION

The brush and small trees on the downstream slope is a deficiency which should be corrected by establishing a regular maintenance program. The water flowing from the abandoned spillway outlet is considered a major deficiency for the following reasons; 1) the dam is reported to have been partially breached at this location in the past; 2) the origin of the water was not readily apparent. This deficiency should be investigated and appropriate action taken to correct the causes. An engineer, experienced in the design and construction of dams, should be retained to evaluate the deficiencies noted above.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

No controllable regulating structure exists at this dam.

4.2 MAINTENANCE OF DAM

The presence of the brush and small trees on the downstream slope suggests that the dam is poorly maintained, if at all.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist, therefore no maintenance records were available.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

4.5 EVALUATION

In our opinion, a regular program of vegetation control is desirable. The water flowing from the abandoned spillway pipe should be monitored for quantity of flow and sedimentation on a regular basis. An engineer experienced in the design of dams should be retained to design appropriate remedial measures.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No design data available.

b. Experience Data. The drainage area and lake surface area are developed from USGS Pinnacle Lake Mo. Quadrangle. The spillway and dam layout are from surveys made during the inspection.

c. Visual Observations.

(1) The spillway, outlet pipe, pool, and the exit channel are in good condition.

(2) The spillway is located adjacent to Station 5+67 (See Plate 3). Spillway discharge will not endanger the integrity of the dam.

(3) The abandoned spillway pipe, although partially closed with a welded steel plate, was flowing at an estimated rate of 80 g.p.m.

d. Overtopping Potential. The spillway has been found to be inadequate to pass the Probable Maximum Flood (PMF) without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.

For the PMF, the dam would be overtopped to a maximum height of approximately 16.7 feet with a duration of overtopping of approximately 14.5 hours with a maximum discharge rate of 22942 cfs. In our opinion, failure of the dam may be expected to occur as a result of overtopping for this length of time.

For 50% of the P.M.F., the dam would be overtopped to a maximum height of approximately 8.7 feet, with a duration of overtopping of approximately 12.2 hours, with a maximum discharge rate of approximately 11430 cfs.

The spillway has been found to be adequate to pass a flood of approximately five (5%) percent of the PMF.

The spillway have also been found to be inadequate to pass the 100 year flood, which has a 1% chance of being equalled or exceeded at least once during any given year.

The estimated damage zone extends six miles downstream of the dam. Immediately downstream of the dam is a trailer camping area. Within the damage zone are three farmhouses and three farm complexes. The floodplain is farmed.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visually observed conditions which can affect the structural stability of this dam have been discussed in Section 3.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam were found except that discussed in Section 1.2.

c. Operating Records. No records were available.

d. Post-Construction Changes. No post-construction changes other than referenced in Section 1.2 g were observed.

e. Seismic Stability. The location of Pinnacle Lake Dam is in Seismic Zone 1. No engineering data was available to evaluate the seismic stability, however to our knowledge, an earthquake of the magnitude that may reasonably be expected in Seismic Zone 1 has notcaused a structural collapse of a dam of this size.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM AND SPILLWAY ASSESSMENT

a. Safety

(1) Dam. Corrective measures should be taken for the deficiencies visually observed by the inspection team, i.e. brush and some small trees on the embankment, water flowing from the abandoned pipe.

The source of water flowing from the abandoned pipe is considered a major deficiency and the cause should be determined and proper measures taken for elimination or control of flow.

(2) Spillway. The spillway, will not pass the Probable Maximum Flood without overtopping the dam. In addition, the spillway will not pass the 100 year, (1% chance) flood, without overtopping the dam.

(3) In our opinion, the services of a professional engineer experienced in the design of dams should be obtained to evaluate these deficiencies.

b. Adequacy of Information. Due to lack of engineering design and construction data, except that discussed in Section 1, the conclusions of this report were based on performance and external visual conditions. Some geologic reports, prepared by the Missouri Geological Survey, were made available and were considered in the preparation of this report. The lack of seepage and stability analyses comparable to the requirements of the recommended guidelines is a deficiency which should be corrected. The inspection team considers that these data are sufficient to support the conclusions herein.

7.2 REMEDIAL MEASURES

a. O&M Procedures. The following O&M procedures are recommended:

(1) The abandoned spillway pipe should be filled or plugged.

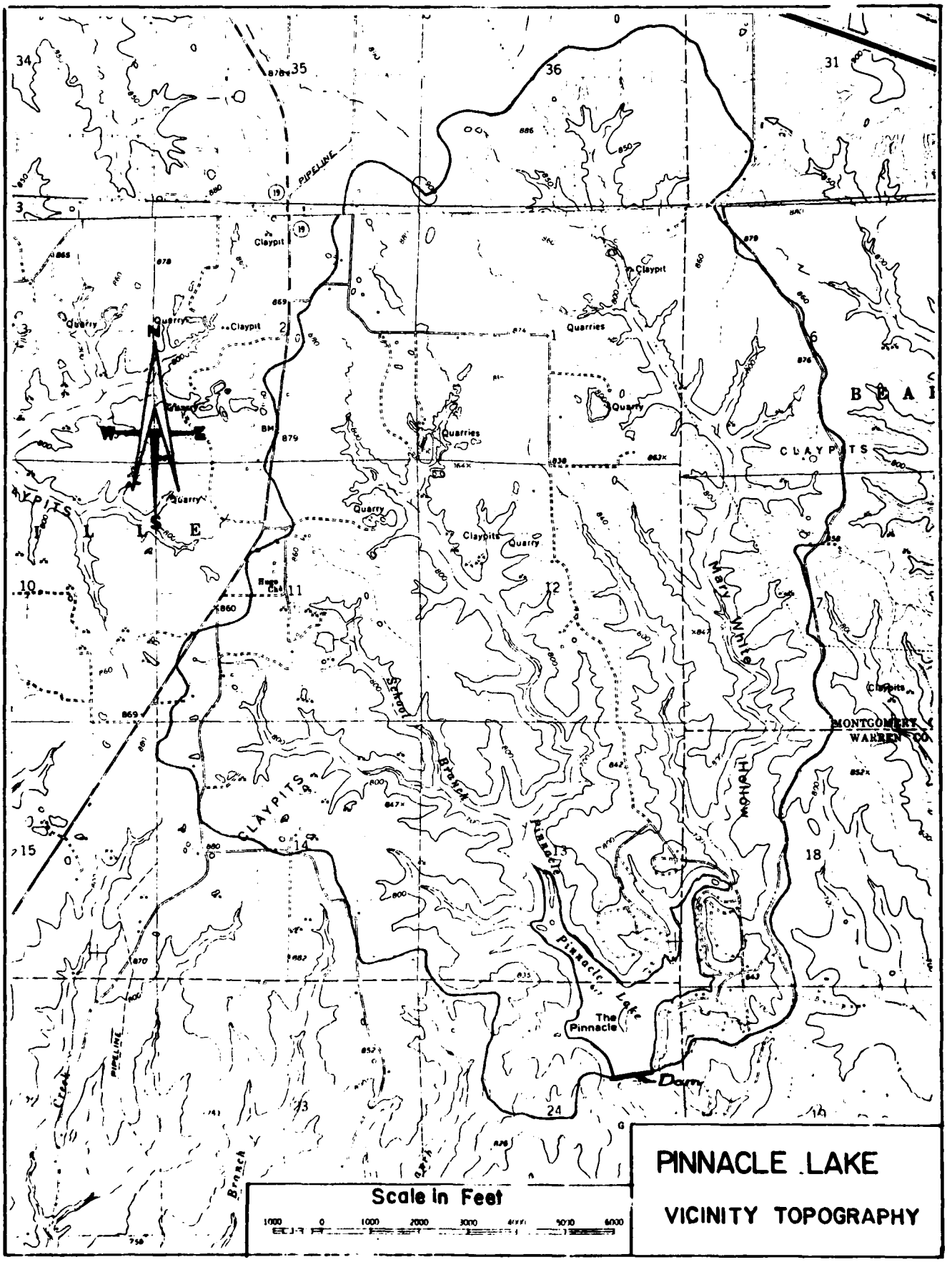
(2) Brush and excessive vegetation should be removed from the embankment slopes.

(3) Up-to-date records of all maintenance and repairs should be kept.

(4) Spillway capacities and/or height of dam should be increased to pass 100 percent (100%) of the Probable Maximum Flood.

(5) The dam should be periodically inspected by an Engineer experienced in the design and construction of dams, and records kept of these inspections.

(6) Stability and seepage analyses should be performed by a professional engineer experienced in the design and construction of dams.


PINNACLE LAKE
VICINITY TOPOGRAPHY
Scale in Feet
1000 0 1000 2000 3000 4000 5000 6000
PLATE I
PIPELINE
Claypit
Quarry
Quarries
CLAYPITS
Claypits
Quarry
Dam
The Pinnacle
Pinnacle Lake
Branch
Creek
MONTGOMERY CO.
WARREN CO.
BEAR
N
W
E
S

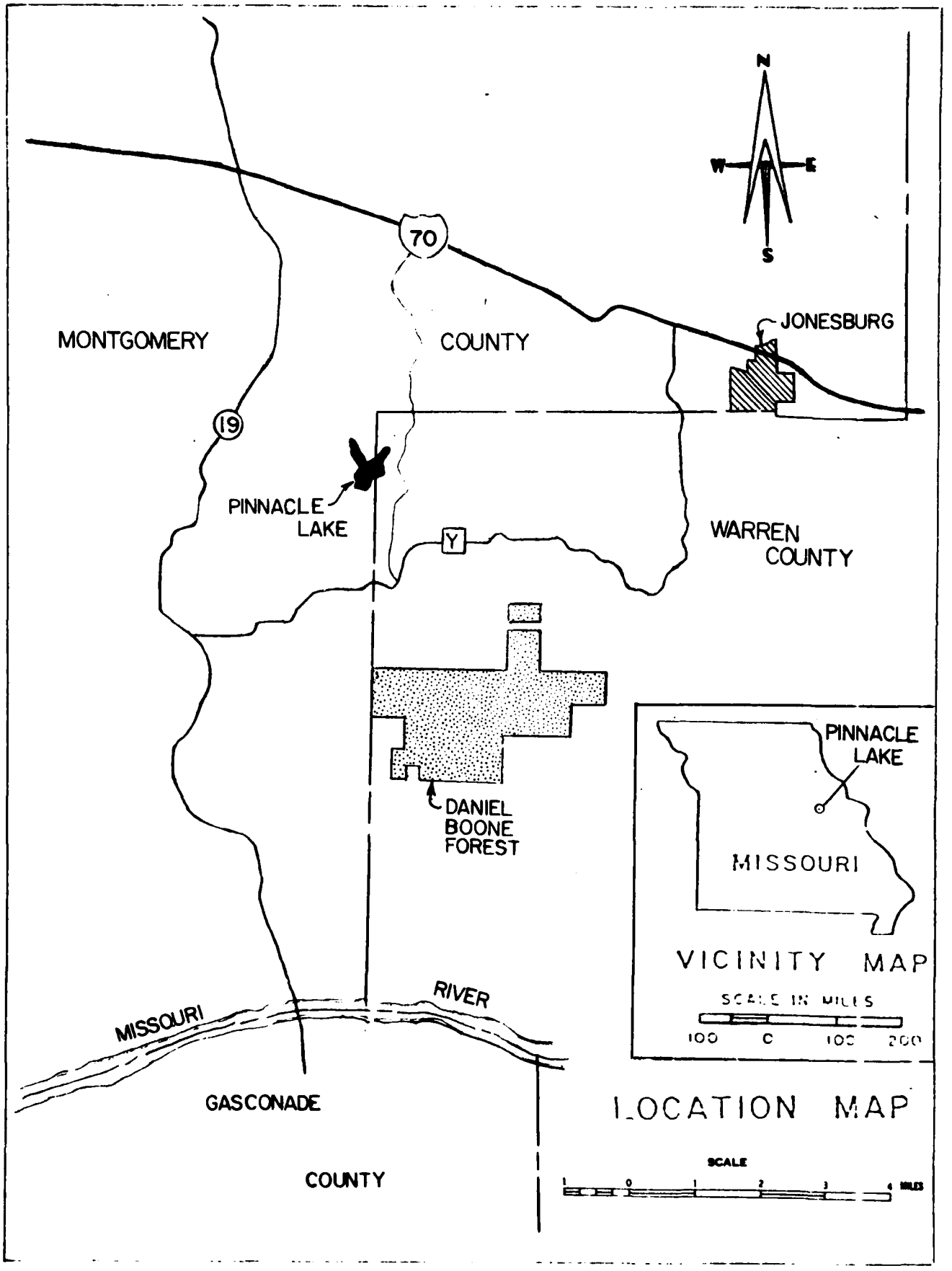
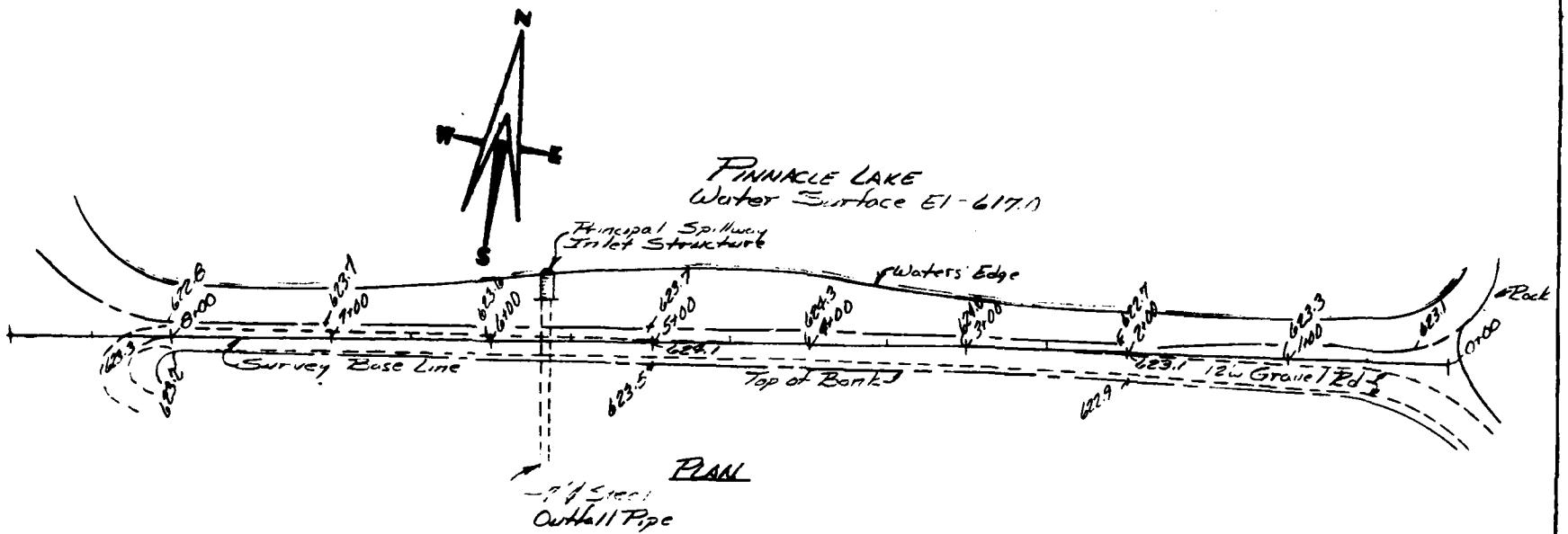

N
W
E
S
70
JONESBURG
MONTGOMERY
COUNTY
19
PINNACLE
LAKE
Y
WARREN
COUNTY
DANIEL
BOONE
FOREST
PINNACLE
LAKE
MISSOURI
VICINITY MAP
SCALE IN MILES
100
0
100
200
RIVER
MISSOURI
GASCONADE
COUNTY
LOCATION MAP
SCALE
0
1
2
3
4
MILES

PLATE 2

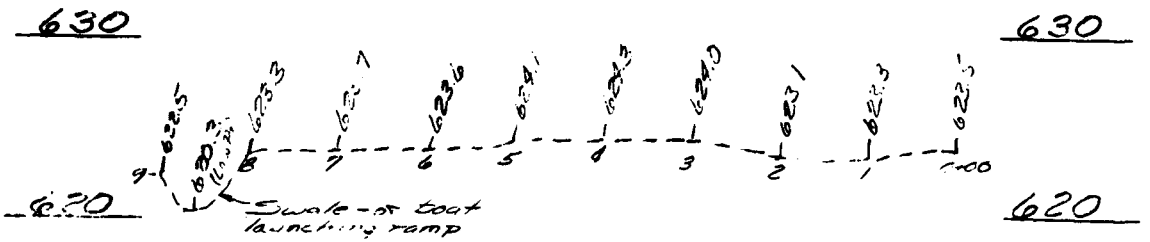


PINNACLE LAKE

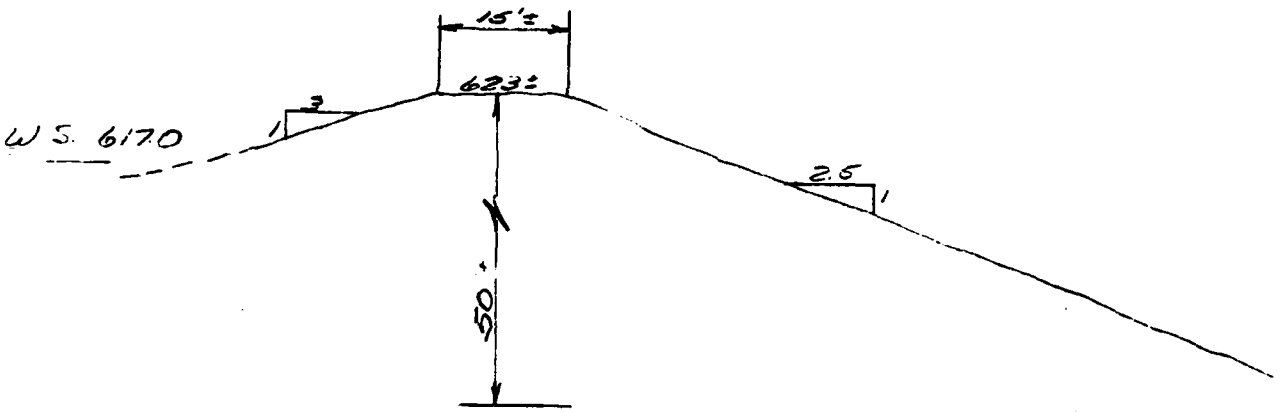
TOP OF DAM ELEVATIONS

SCALE: 1"=100'

PLATE 3



PROFILE
1" = 200' Horiz
SCALE: 1" = 10' Vert.



TYPICAL CROSS SECTION
SCALE: 1" = 20' Horiz & Vert.

PINNACLE LAKE
DAM PROFILE
and CROSS SECTION

PLATE 4

PHOTO 1 Overview of Lake and Dam

PHOTO 2 Crest of Dam

PHOTO 3 Rock Outcrop on East Abutment

PHOTO 4 Old Spillway Outlet Works

PHOTO 5 Principal Spillway Entrance

PHOTO 6 Spillway Exit

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES METHODOLOGY

HYDROLOGIC AND HYDRAULIC ANALYSIS METHODOLOGY

1. The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for a reservoir routing. The Probable Maximum Precipitation is derived and determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors have not been applied. A 24-hour storm duration is assumed with the total rainfall depth distributed over 6-hour periods in accordance with procedures outlined in EM 1110-2-1411 (SPF Determination). The maximum 6-hour rainfall period is then distributed to hourly increments by the same criteria. Within-the-hour distribution is based upon NOAA Technical Memorandum NWS HYDRO-35. The nonpeak 6-hour rainfall periods are distributed uniformly. All distributed values are arranged in a critical sequence by the SPF criteria. The final inflow hydrograph is produced by utilizing the Soil Conservation Service dimensionless unit hydrograph using Hydrologic Soils Group "D", Antecedent Moisture Condition III, and SCS CN 93 used to determine rainfall excess.

Lag time was estimated using methods outlined in "Design of Small Dams", by the United States Department of The Interior, Bureau of Reclamation. Using this source, lag time is taken as 60% of the time of concentration.

Time of concentration was estimated utilizing methods outlined in the source quoted above, supplemented by data obtained during field investigation. The results of the field investigation and the computations indicated that a time of 3.5 hours was appropriate. For this lake, a lag time of 2.1 hours was therefore selected.

2. The reservoir routing is accomplished by using Modified Puls routing techniques wherein the flood hydrograph is routed through lake storage. Hydraulic capacities of the outlet works, spillway, and crest of dam are used as outlet controls in the routing. Storage in the pool area is defined by an elevation-storage capacity curve. The hydraulic capacity of the outlet works, spillway, and top of dam are defined by elevation-discharge curves.

3. Dam overtopping analysis has been conducted by hydrologic methods for this dam and lake. This computation determines the percentage of the PMF hydrograph that the reservoir can contain without the dam being overtopped. An output summary in the hydrologic appendix displays this information as well as other characteristics of the simulated dam overtopping.

4. The above methodology has been accomplished for this report using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The numeric parameters estimated for this site are listed in the attached computer printout. Definitions of these variables are contained in the "User's Manual" for the computer program.

5. The inflow hydrograph was routed through the reservoir using HEC-1's Modified Puls option. Releases were calculated for: 1) the spillway, and 2) the flow over the top of the dam. These releases were then combined at each of their respective elevations.

Flow through the drop structure and pipe outlet at the spillway was obtained by considering the drop structure as a weir.

For the weir.

$$Q = CL(H)^{1.5}$$

where: C = Varies with head as outlined in "Handbook of Hydraulics" by Horace Williams King, revised by Ernest F. Brater.

L = Length in feet = 49.2.

H = Head of water in feet (varies with water surface)

Q = Discharge in cfs

Flow through over the top of dam was calculated using the weir flow equation:

$$Q = CL(H)^{1.5}$$

where: C = Varies with head as outlined in "Handbook of Hydraulics" by Horace Williams King, revised by Ernest F. Brater.

L = Length in feet (varies with water surface)

H = Head of water in feet (varies with water surface)

Q = Discharge in cfs

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  1 AUG 78
**********
    1                 A1                                   PINNACLE  LAKE
    2                 A2                                    OCT 30 1978
    3                 A3                                   NO INV. NO.30923
    4                 B    288      -0        5       -0       -0       -0       -0       -0       -4       -0
    5                 B1     5
    6                 J      1       6         1
    7                 J1   .05     .10       .15      .20      .50     1.00
    8                 K      0  INFLOW                                      3                                1
    9                 M      1       2      7.42                           1
   10                 P             26       100      120      130
   11                 T                                                                -1       -93                .04
   12                 W2            2.10
   13                 X   14.84     -.1         3
   14                 K      1  ROUTING                                  2        2
   15                 Y                                          1       1
   16                 Y1     1                                                        -617.00     -1
   17                 Y4617.00    617.50    618.00   618.50   619.00   619.50   620.00   620.50   621.00   621.50
   18                 Y4622.00    622.50    623.00   623.50   624.00
   19                 Y5     0     50.50    146.70   246.81   460.88   646.04   849.24  1072.63  1359.68  1698.77
   20                 Y52052.3  2419.54   2875.60  3416.49  4304.91
   21                 $S     0     60.38    120.75   184.34   247.93   313.93   381.54   450.35   519.95   590.34
   22                 $$661.52    733.50    806.27   879.83   954.18
   23                 $E617.00    617.50    618.00   618.50   619.00   619.50   620.00   620.50   621.00   621.50
   24                 $E622.00    622.50    623.00   623.50   624.00
   25                 $$617.00
   26                 $0620.30
   27                 K     99
```

COMPUTER INPUT DATA

```
1000 HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  3 AUG 78

RUN  DATE= 11/16/78.
     TIME= 16.27.41.
```

PINNACLE LAKE
OCT 30 1978
MO INV. NO.30923

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	-0	5	-0	-0	-0	-0	-0	-4	-0
			JOPER	NWT	LROPT	TRACE			
			5	-0	-0	-0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 6 LRTIO= 1

RTIOS=	.05	.10	.15	.20	.50	1.00

SUB-AREA RUNOFF COMPUTATION

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW	0	-0	-0	-0	3	-0	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	7.42	-0.00	7.42	1.00	-0.000	-0	1	-0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
-0.00	24.00	100.00	120.00	130.00	-0.00	-0.00	-0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.00	-0.00	1.00	-0.00	-0.00	1.00	-1.00	-93.00	-0.00	.04

CURVE NO = -93.00 WETNESS = -1.00 EFFECT CN = 93.00

UNIT HYDROGRAPH DATA
TC= -0.00 LAG= 2.10

RECESSION DATA
STRTQ= 14.84 QRCSN= -.10 RTIOR= 3.00

INPUT UNIT HYDROGRAPH

UNIT HYDROGRAPH 128 END-OF-PERIOD ORDINATES, TC= -0.00 HOURS, LAG= 2.10 VOL= 1.00

20.	34.	70.	115.	161.	218.	276.	340.	419.	497.
594.	692.	805.	928.	1052.	1164.	1269.	1372.	1444.	1516.
1573.	1612.	1651.	1662.	1668.	1671.	1664.	1658.	1627.	1588.
1564.	1503.	1457.	1408.	1356.	1303.	1238.	1173.	1102.	1024.
964.	874.	814.	755.	710.	664.	623.	584.	546.	514.
491.	454.	430.	407.	383.	359.	337.	318.	298.	279.
259.	242.	229.	216.	203.	190.	177.	167.	158.	148.

				57.	53.	50.	47.	44.	42.	
	34.	36.	34.	32.	30.	28.	26.	25.	23.	22.
	21.	19.	18.	17.	17.	16.	15.	14.	14.	13.
	12.	11.	10.	10.	9.	8.	7.	7.	6.	6.
	5.	4.	4.	3.	2.	2.	1.	0.		

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	13.	1.01	12.05	145	.22	.21	.00	3916.
1.01	.10	2	.01	.00	.01	12.	1.01	12.10	144	.22	.21	.00	3932.
1.01	.15	3	.01	.00	.01	11.	1.01	12.15	147	.22	.21	.00	3952.
1.01	.20	4	.01	.00	.01	10.	1.01	12.20	148	.22	.21	.00	3977.
1.01	.25	5	.01	.00	.01	9.	1.01	12.25	149	.22	.21	.00	4009.
1.01	.30	6	.01	.00	.01	8.	1.01	12.30	150	.22	.21	.00	4049.
1.01	.35	7	.01	.00	.01	7.	1.01	12.35	151	.22	.21	.00	4096.
1.01	.40	8	.01	.00	.01	7.	1.01	12.40	152	.22	.22	.00	4152.
1.01	.45	9	.01	.00	.01	6.	1.01	12.45	153	.22	.22	.00	4219.
1.01	.50	10	.01	.00	.01	6.	1.01	12.50	154	.22	.22	.00	4297.
1.01	.55	11	.01	.00	.01	6.	1.01	12.55	155	.22	.22	.00	4389.
1.01	1.00	12	.01	.00	.01	6.	1.01	13.00	156	.22	.22	.00	4495.
1.01	1.05	13	.01	.00	.01	6.	1.01	13.05	157	.26	.26	.00	4617.
1.01	1.10	14	.01	.00	.01	6.	1.01	13.10	158	.26	.26	.00	4757.
1.01	1.15	15	.01	.00	.01	7.	1.01	13.15	159	.26	.26	.00	4916.
1.01	1.20	16	.01	.00	.01	7.	1.01	13.20	160	.26	.26	.00	5093.
1.01	1.25	17	.01	.00	.01	8.	1.01	13.25	161	.26	.26	.00	5287.
1.01	1.30	18	.01	.00	.01	9.	1.01	13.30	162	.26	.26	.00	5498.
1.01	1.35	19	.01	.00	.01	10.	1.01	13.35	163	.26	.26	.00	5721.
1.01	1.40	20	.01	.00	.01	12.	1.01	13.40	164	.26	.26	.00	5957.
1.01	1.45	21	.01	.00	.01	13.	1.01	13.45	165	.26	.26	.00	6205.
1.01	1.50	22	.01	.01	.01	16.	1.01	13.50	166	.26	.26	.00	6462.
1.01	1.55	23	.01	.01	.01	18.	1.01	13.55	167	.26	.26	.00	6728.
1.01	2.00	24	.01	.01	.01	21.	1.01	14.00	168	.26	.26	.00	7001.
1.01	2.05	25	.01	.01	.01	24.	1.01	14.05	169	.32	.32	.00	7280.
1.01	2.10	26	.01	.01	.01	27.	1.01	14.10	170	.32	.32	.00	7565.
1.01	2.15	27	.01	.01	.01	31.	1.01	14.15	171	.32	.32	.00	7858.
1.01	2.20	28	.01	.01	.01	36.	1.01	14.20	172	.32	.32	.00	8157.
1.01	2.25	29	.01	.01	.01	41.	1.01	14.25	173	.32	.32	.00	8459.
1.01	2.30	30	.01	.01	.01	47.	1.01	14.30	174	.32	.32	.00	8764.
1.01	2.35	31	.01	.01	.01	53.	1.01	14.35	175	.32	.32	.00	9070.
1.01	2.40	32	.01	.01	.01	59.	1.01	14.40	176	.32	.32	.00	9376.
1.01	2.45	33	.01	.01	.01	67.	1.01	14.45	177	.32	.32	.00	9684.
1.01	2.50	34	.01	.01	.01	74.	1.01	14.50	178	.32	.32	.00	9991.
1.01	2.55	35	.01	.01	.01	82.	1.01	14.55	179	.32	.32	.00	10298.
1.01	3.00	36	.01	.01	.01	91.	1.01	15.00	180	.32	.32	.00	10606.
1.01	3.05	37	.01	.01	.01	100.	1.01	15.05	181	.20	.20	.00	10908.
1.01	3.10	38	.01	.01	.01	109.	1.01	15.10	182	.40	.39	.00	11211.
1.01	3.15	39	.01	.01	.01	119.	1.01	15.15	183	.40	.39	.00	11512.
1.01	3.20	40	.01	.01	.01	130.	1.01	15.20	184	.59	.59	.00	11812.
1.01	3.25	41	.01	.01	.01	140.	1.01	15.25	185	.69	.69	.00	12115.
1.01	3.30	42	.01	.01	.01	151.	1.01	15.30	186	1.68	1.68	.00	12443.
1.01	3.35	43	.01	.01	.01	162.	1.01	15.35	187	2.77	2.76	.00	12820.
1.01	3.40	44	.01	.01	.01	173.	1.01	15.40	188	1.09	1.09	.00	13228.
1.01	3.45	45	.01	.01	.01	184.	1.01	15.45	189	.69	.69	.00	13687.
1.01	3.50	46	.01	.01	.00	196.	1.01	15.50	190	.59	.59	.00	14195.
1.01	3.55	47	.01	.01	.00	208.	1.01	15.55	191	.40	.39	.00	14731.
1.01	4.00	48	.01	.01	.00	219.	1.01	16.00	192	.40	.39	.00	15305.
1.01	4.05	49	.01	.01	.00	231.	1.01	16.05	193	.30	.30	.00	15902.
1.01	4.10	50	.01	.01	.00	243.	1.01	16.10	194	.30	.30	.00	16536.
1.01	4.15	51	.01	.01	.00	255.	1.01	16.15	195	.30	.30	.00	17213.
1.01	4.20	52	.01	.01	.00	267.	1.01	16.20	196	.30	.30	.00	17927.
1.01	4.25	53	.01	.01	.00	278.	1.01	16.25	197	.30	.30	.00	18700.
1.01	4.30	54	.01	.01	.00	290.	1.01	16.30	198	.30	.30	.00	19508.
1.01	4.35	55	.01	.01	.00	301.	1.01	16.35	199	.30	.30	.00	20350.
1.01	4.40	56	.01	.01	.00	312.	1.01	16.40	200	.30	.30	.00	21224.

INPUT UNIT HYDROGRAPH

1.01	[illegible]	[illegible]	.01	.01	.00	334.	1.01	16.5	20.	.30	30		
1.01	4.55	59	.01	.01	.00	345.	1.01	16.55	203	.30	.30	.00	23668.
1.01	5.00	60	.01	.01	.00	356.	1.01	17.00	204	.30	.30	.00	24371.
1.01	5.05	61	.01	.01	.00	366.	1.01	17.05	205	.24	.24	.00	24965.
1.01	5.10	62	.01	.01	.00	376.	1.01	17.10	206	.24	.24	.00	25492.
1.01	5.15	63	.01	.01	.00	386.	1.01	17.15	207	.24	.24	.00	25927.
1.01	5.20	64	.01	.01	.00	396.	1.01	17.20	208	.24	.24	.00	26271.
1.01	5.25	65	.01	.01	.00	406.	1.01	17.25	209	.24	.24	.00	26542.
1.01	5.30	66	.01	.01	.00	415.	1.01	17.30	210	.24	.24	.00	26707.
1.01	5.35	67	.01	.01	.00	424.	1.01	17.35	211	.24	.24	.00	26812.
1.01	5.40	68	.01	.01	.00	433.	1.01	17.40	212	.24	.24	.00	26861.
1.01	5.45	69	.01	.01	.00	442.	1.01	17.45	213	.24	.24	.00	26851.
1.01	5.50	70	.01	.01	.00	450.	1.01	17.50	214	.24	.24	.00	26783.
1.01	5.55	71	.01	.01	.00	459.	1.01	17.55	215	.24	.24	.00	26624.
1.01	6.00	72	.01	.01	.00	467.	1.01	18.00	216	.24	.24	.00	26407.
1.01	6.05	73	.07	.06	.01	476.	1.01	18.05	217	.02	.02	.00	26149.
1.01	6.10	74	.07	.06	.01	485.	1.01	18.10	218	.02	.02	.00	25847.
1.01	6.15	75	.07	.06	.01	496.	1.01	18.15	219	.02	.02	.00	25512.
1.01	6.20	76	.07	.06	.01	509.	1.01	18.20	220	.02	.02	.00	25136.
1.01	6.25	77	.07	.06	.01	524.	1.01	18.25	221	.02	.02	.00	24723.
1.01	6.30	78	.07	.06	.01	542.	1.01	18.30	222	.02	.02	.00	24264.
1.01	6.35	79	.07	.06	.01	562.	1.01	18.35	223	.02	.02	.00	23748.
1.01	6.40	80	.07	.06	.01	586.	1.01	18.40	224	.02	.02	.00	23191.
1.01	6.45	81	.07	.06	.01	613.	1.01	18.45	225	.02	.02	.00	22584.
1.01	6.50	82	.07	.06	.01	644.	1.01	18.50	226	.02	.02	.00	21937.
1.01	6.55	83	.07	.07	.01	679.	1.01	18.55	227	.02	.02	.00	21275.
1.01	7.00	84	.07	.07	.01	720.	1.01	19.00	228	.02	.02	.00	20619.
1.01	7.05	85	.07	.07	.01	766.	1.01	19.05	229	.02	.02	.00	19963.
1.01	7.10	86	.07	.07	.01	819.	1.01	19.10	230	.02	.02	.00	19317.
1.01	7.15	87	.07	.07	.01	877.	1.01	19.15	231	.02	.02	.00	18688.
1.01	7.20	88	.07	.07	.01	942.	1.01	19.20	232	.02	.02	.00	18056.
1.01	7.25	89	.07	.07	.00	1012.	1.01	19.25	233	.02	.02	.00	17427.
1.01	7.30	90	.07	.07	.00	1087.	1.01	19.30	234	.02	.02	.00	16794.
1.01	7.35	91	.07	.07	.00	1166.	1.01	19.35	235	.02	.02	.00	16164.
1.01	7.40	92	.07	.07	.00	1250.	1.01	19.40	236	.02	.02	.00	15541.
1.01	7.45	93	.07	.07	.00	1337.	1.01	19.45	237	.02	.02	.00	14923.
1.01	7.50	94	.07	.07	.00	1426.	1.01	19.50	238	.02	.02	.00	14319.
1.01	7.55	95	.07	.07	.00	1517.	1.01	19.55	239	.02	.02	.00	13724.
1.01	8.00	96	.07	.07	.00	1610.	1.01	20.00	240	.02	.02	.00	13135.
1.01	8.05	97	.07	.07	.00	1704.	1.01	20.05	241	.02	.02	.00	12554.
1.01	8.10	98	.07	.07	.00	1798.	1.01	20.10	242	.02	.02	.00	11981.
1.01	8.15	99	.07	.07	.00	1892.	1.01	20.15	243	.02	.02	.00	11422.
1.01	8.20	100	.07	.07	.00	1986.	1.01	20.20	244	.02	.02	.00	10877.
1.01	8.25	101	.07	.07	.00	2080.	1.01	20.25	245	.02	.02	.00	10346.
1.01	8.30	102	.07	.07	.00	2171.	1.01	20.30	246	.02	.02	.00	9831.
1.01	8.35	103	.07	.07	.00	2261.	1.01	20.35	247	.02	.02	.00	9335.
1.01	8.40	104	.07	.07	.00	2349.	1.01	20.40	248	.02	.02	.00	8863.
1.01	8.45	105	.07	.07	.00	2435.	1.01	20.45	249	.02	.02	.00	8416.
1.01	8.50	106	.07	.07	.00	2519.	1.01	20.50	250	.02	.02	.00	7988.
1.01	8.55	107	.07	.07	.00	2600.	1.01	20.55	251	.02	.02	.00	7576.
1.01	9.00	108	.07	.07	.00	2679.	1.01	21.00	252	.02	.02	.00	7182.
1.01	9.05	109	.07	.07	.00	2754.	1.01	21.05	253	.02	.02	.00	6809.
1.01	9.10	110	.07	.07	.00	2827.	1.01	21.10	254	.02	.02	.00	6460.
1.01	9.15	111	.07	.07	.00	2895.	1.01	21.15	255	.02	.02	.00	6131.
1.01	9.20	112	.07	.07	.00	2960.	1.01	21.20	256	.02	.02	.00	5822.
1.01	9.25	113	.07	.07	.00	3021.	1.01	21.25	257	.02	.02	.00	5533.
1.01	9.30	114	.07	.07	.00	3078.	1.01	21.30	258	.02	.02	.00	5264.
1.01	9.35	115	.07	.07	.00	3132.	1.01	21.35	259	.02	.02	.00	5017.
1.01	9.40	116	.07	.07	.00	3183.	1.01	21.40	260	.02	.02	.00	4786.
1.01	9.45	117	.07	.07	.00	3231.	1.01	21.45	261	.02	.02	.00	4568.
1.01	9.50	118	.07	.07	.00	3277.	1.01	21.50	262	.02	.02	.00	4362.
1.01	9.55	119	.07	.07	.00	3320.	1.01	21.55	263	.02	.02	.00	4170.
1.01	10.00	120	.07	.07	.00	3360.	1.01	22.00	264	.02	.02	.00	3992.
1.01	10.05	121	.07	.07	.00	3399.	1.01	22.05	265	.02	.02	.00	3826.
1.01	10.10	122	.07	.07	.00	3436.	1.01	22.10	266	.02	.02	.00	3670.

INPUT UNIT HYDROGRAPH

1.01	20	24			.0	35	1.01				.0	.00	3383.
1.01	10.25	125	.07	.07	.00	3535.	1.01	22.25	269	.02	.02	.00	3252.
1.01	10.30	126	.07	.07	.00	3565.	1.01	22.30	270	.02	.02	.00	3130.
1.01	10.35	127	.07	.07	.00	3593.	1.01	22.35	271	.02	.02	.00	3013.
1.01	10.40	128	.07	.07	.00	3620.	1.01	22.40	272	.02	.02	.00	2903.
1.01	10.45	129	.07	.07	.00	3646.	1.01	22.45	273	.02	.02	.00	2800.
1.01	10.50	130	.07	.07	.00	3670.	1.01	22.50	274	.02	.02	.00	2703.
1.01	10.55	131	.07	.07	.00	3693.	1.01	22.55	275	.02	.02	.00	2613.
1.01	11.00	132	.07	.07	.00	3715.	1.01	23.00	276	.02	.02	.00	2528.
1.01	11.05	133	.07	.07	.00	3735.	1.01	23.05	277	.02	.02	.00	2449.
1.01	11.10	134	.07	.07	.00	3755.	1.01	23.10	278	.02	.02	.00	2374.
1.01	11.15	135	.07	.07	.00	3773.	1.01	23.15	279	.02	.02	.00	2304.
1.01	11.20	136	.07	.07	.00	3791.	1.01	23.20	280	.02	.02	.00	2238.
1.01	11.25	137	.07	.07	.00	3808.	1.01	23.25	281	.02	.02	.00	2176.
1.01	11.30	138	.07	.07	.00	3823.	1.01	23.30	282	.02	.02	.00	2117.
1.01	11.35	139	.07	.07	.00	3838.	1.01	23.35	283	.02	.02	.00	2062.
1.01	11.40	140	.07	.07	.00	3852.	1.01	23.40	284	.02	.02	.00	2011.
1.01	11.45	141	.07	.07	.00	3866.	1.01	23.45	285	.02	.02	.00	1963.
1.01	11.50	142	.07	.07	.00	3879.	1.01	23.50	286	.02	.02	.00	1916.
1.01	11.55	143	.07	.07	.00	3891.	1.01	23.55	287	.02	.02	.00	1876.
1.01	12.00	144	.07	.07	.00	3902.	1.02	0.00	288	.02	.02	.00	1837.
									SUM	33.80	32.95	.85	1844644.
										(859.)	(837.)	(22.)	(52234.50)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	26861.	18331.	6402.	6402.	1843730.
CMS	761.	519.	181.	181.	52209.
INCHES		22.98	32.10	32.10	32.10
MM		583.71	815.43	815.43	815.43
AC-FT		9090.	12698.	12698.	12698.
THOUS CU M		11212.	15663.	15663.	15663.

HYDROGRAPH AT STAINFLOW FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1343.	917.	320.	320.	92187.
CMS	38.	26.	9.	9.	2610.
INCHES		1.15	1.61	1.61	1.61
MM		29.19	40.77	40.77	40.77
AC-FT		454.	635.	635.	635.
THOUS CU M		561.	783.	783.	783.

HYDROGRAPH AT STAINFLOW FOR PLAN 1, RTIO 2

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2686.	1833.	640.	640.	184373.
CMS	76.	52.	18.	18.	5221.
INCHES		2.30	3.21	3.21	3.21
MM		58.37	81.54	81.54	81.54
AC-FT		909.	1270.	1270.	1270.
THOUS CU M		1121.	1566.	1566.	1566.

HYDROGRAPH AT STAINFLOW FOR PLAN 1, RTIO 3

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4029.	2750.	960.	960.	276560.
CMS	114.	78.	27.	27.	7831.
INCHES		3.45	4.82	4.82	4.82

INPUT UNIT HYDROGRAPH

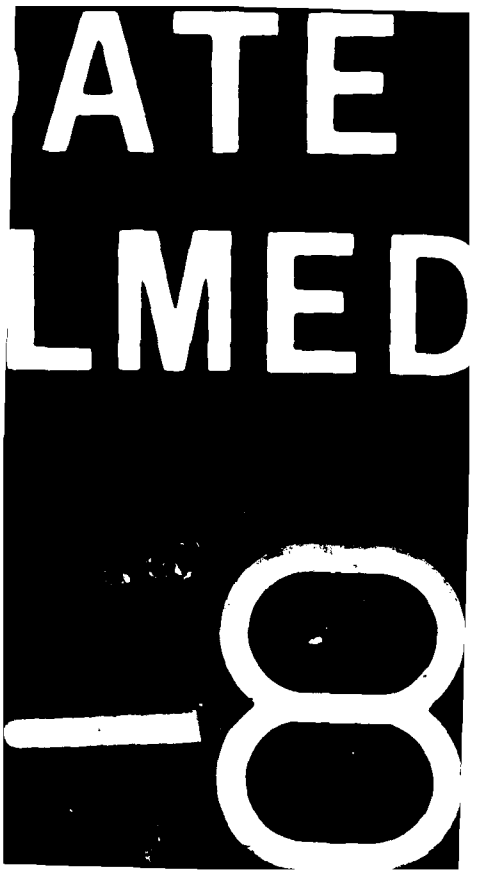
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	617.00	617.00	620.30
STORAGE	0.	0.	423.
OUTFLOW	0.	0.	983.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	619.67	0.00	338.	717.	0.00	19.83	0.00
.10	621.50	1.20	590.	1696.	5.50	19.50	0.00
.15	622.93	2.63	796.	2809.	7.75	19.25	0.00
.20	623.95	3.65	947.	4238.	8.58	18.92	0.00
.50	628.99	8.69	1695.	11430.	12.25	18.75	0.00
1.00	637.04	16.74	2893.	22942.	14.50	18.67	0.00

COMPUTER SUMMARY ANALYSIS


ATE
LMED
8